SUMMARY REPORT OF THE DISTRIBUTION, ABUNDANCE, AND HABITAT CHARACTERISTICS OF THE BUFF-BREASTED FLYCATCHER IN THE CHIRICAHUA, SANTA CATALINA, AND RINCON MOUNTAINS OF ARIZONA, 1996

15 June, 1997

prepared for

Arizona Game and Fish Department
2221 W. Greenway Road
Phoenix, AZ 85023

by

School of Renewable Natural Resources
Wildlife and Fisheries Sciences Program
325 Biological Sciences East
University of Arizona
Tucson, AZ 85721

Principal Investigator: Dr. Michael L. Morrison

Project Leader: John Martin

DISCLAIMER

Table of Contents

List of Tables

List of Appendices

STATEMENT BY AUTHOR

The material presented in this report pertains only to data collected in 1996, primarily in the Chiricahua Mountains. These data were collected as part of a more extensive study, incorporating data collected in 1995 and 1996 in the Huachuca, Chiricahua, Santa Rita, Santa Catalina, and Rincon, and Whetstone mountains. For a detailed and extensive report on the study area and methods used, and findings and recommendations generated by the entire study, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004.

ABSTRACT

Geographic range and numbers of buff-breasted flycatchers (Empidonax fulvifrons) have decreased in Arizona. Presently the species is known to occupy only a few areas in the Huachuca, Chiricahua, and Santa Catalina mountains. We conducted extensive surveys in southeast Arizona mountain ranges in an effort to locate additional breeding populations. Comparison of our results with prior records suggested that small populations have disappeared in the last 15 years, but that other small populations have increased in size. We estimated reproductive success of birds found using an index based on regular observations of adults' behavior. We measured vegetation structure and floristics in areas used by buff-breasted flycatchers, at nest sites within those used areas, and available areas. We used logistic regression to compare used to available areas and nest sites to used areas. Used vs. available comparisons indicated that buff-breasted flycatchers used areas dominated by pines, with a sparse oak-juniper understory. Nest sites differed from used areas in a denser tall pine canopy and less woody understory cover. Differences found between successful and unsuccessful used areas or nest sites were probably not biologically significant. We found significant associations between buff-breasted flycatcher presence and vegetation type, forest structural stage, canopy cover, and forest patch width at buff-breasted flycatcher survey points. Observations of unoccupied apparently suitable habitat suggested that buff-breasted flycatcher distribution was not strictly limited by potential habitat availability. We used habitat characteristics associated with occupation of an area to develop a habitat model to help manage this rare species. We recommend continued monitoring of buff-breasted flycatcher populations and creation of open pine forest with an open understory of oak. Fire may facilitate development of potential habitat.

INTRODUCTION

The buff-breasted flycatcher (Empidonax fulvifrons) is currently a rare, patchily distributed bird in the mountains of southeastern Arizona. It has declined in numbers and geographic range since the 1920s (Phillips et al. 1964). This species is on the draft list of Wildlife of Special Concern (Arizona Game and Fish Department 1996) According to a prioritization scheme intended to identify species most in need of conservation action and/or study (Hunter et al. 1992), the buff-breasted flycatcher in Arizona has a "concern score" of 26-28, placing it in the "very high priority" category.

The buff-breasted flycatcher has apparently never been an abundant bird in Arizona. Some turn-of-the-century ornithologists (Howard 1899, Lusk 1901, Swarth 1904, Bent 1942) referred to it as rare. Swarth (1914) stated that this bird was "nowhere very common" and "very locally distributed." More recently Phillips et al. (1964) called it a "rare summer resident, more common and widespread formerly." Bowers (1983) spent 66 days in the field in 1982 searching specifically for buff-breasted flycatchers in the Huachuca and Chiricahua mountains, and found only 36 adults in 8 locations.

There is little published scientific literature concerning the buff-breasted flycatcher. We have found only 4 accounts of the biology of this species written in the last 70 years (Brandt 1951; Bowers 1983, 1984, 1994). Its habitat has not been described quantitatively.

Concern over the buff-breasted flycatcher's decline has led the Arizona Game and Fish Department to fund an investigation, which we have conducted, into this species' current distribution, abundance, and habitat requirements. To determine locations and sizes of breeding populations of buff-breasted flycatchers in southeastern Arizona mountains, we conducted surveys. Where we found buff-breasted flycatchers, we examined their habitat characteristics on three scales: the forest patch, the territory, and the nest site. We used measurements of vegetation structure and floristics, and other habitat variables, to create a multivariate statistical model of buff-breasted flycatcher habitat. Simple presence of a species, or even presence in high densities, is not a reliable indicator of habitat of sufficient quality to sustain a population (Van Horne 1983). Therefore we evaluated reproductive success of the buff-breasted flycatchers found, and determined the habitat variables most significantly correlated with successful reproduction.

OBJECTIVES

1. To determine the location and size of breeding populations of buff-breasted flycatchers in the mountains of southeastern Arizona.
2. To determine whether or not there is a difference between areas within a canyon used by buff-breasted flycatchers and the areas available to the birds, and the nature of that difference.
3. To determine whether there is a difference between the areas used by buff-breasted flycatchers and their nest sites, and the nature of that difference.
4. To determine if buff-breasted flycatchers are associated with particular coarse-grained vegetation attributes at a scale approximating the width of forested area in the canyon bottom usually frequented by buff-breasted flycatchers (about 100 m). By "coarse-grained" we mean characteristics that are usually applied to a large vegetated area, and are usually estimated without intensive measurement of vegetation (e.g., structural stage, vegetation type, width, canopy cover).
5. To determine the relationship between buff-breasted flycatcher occurrence and the width of the

forest patch of potential habitat. By "forest patch" we mean a continuous tree-dominated area separated from other such areas by $\geq$ 100 m.

6. To determine habitat variables associated with successful reproduction in buff-breasted flycatchers.

LITERATURE REVIEW AND CONCEPTUAL DEVELOPMENT

(For a more detailed literature review and conceptual development, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004)

Habitat selection. --To halt the decline of the buff-breasted flycatcher, its habitat requirements must be better understood. Though below we will emphasize the importance of vegetation to the bird's habitat, we have also based much of the conceptual background of this study on resources provided directly by vegetation (e.g., nest sites, escape cover) and the relationship between vegetation and other resources (e.g., arthropod abundance, vegetation structure amenable to foraging by aerial sallies and hover-gleaning) that are important to the buff-breasted flycatcher.

Under the hierarchical habitat selection model proposed by Johnson (1980), habitat selection consists of at least three "orders." First-order selection is the selection of the geographical range of the species. Second-order selection is the selection of a home range containing all of the resources required by an individual for survival and successful reproduction (e.g., food, shelter, mates, nest sites). Third-order selection consists of selection of specific habitat components within that home range. None of these levels of habitat selection are well understood for this species.

By conducting surveys, we investigated first-order habitat selection. We did this to determine if the range of the buff-breasted flycatcher has continued to contract. This helps a manager to determine whether the factors responsible for the species' decline are still in operation, and determine specific areas where efforts to halt buff-breasted flycatcher declines might be most effective.

We investigated second-order habitat selection by the buff-breasted flycatcher to determine if the vegetation and other habitat variables within a used area are different from those available to the birds. If a researcher can identify habitat characteristics within a home range that fulfill all of the bird's life requirements and promote successful reproduction, it may be possible to create potential habitat for the species without the added cost of investigating the use and/or availability of specific resources.

We examined third-order habitat selection by evaluating the difference between nest sites and used areas. Many researchers have noted relationships between vegetation structure and/or floristics and nest site selection by forest-dwelling passerine birds (Martin and Roper 1988; Sakai and Noon 1991; Knopf and Sedgewick 1992; Kelly 1993; Norment 1993). The evidence that nest site selection occurs on more than one scale, and is affected by predation risk, microclimate, and competition suggested that high-quality nest sites may not be as abundant as has been assumed in the past (Martin and Roper 1988, Sakai and Noon 1991). We investigated nest site selection at the scale of vegetation surrounding the nest plant, to determine whether management for buff-breasted flycatchers entails management for nesting habitat that is distinctly different from overall habitat.

Hutto (1985) contended that first-order selection (selection of geographic range) is based on extrinsic factors. This species' pattern of first-order habitat selection is changing. This flycatcher's range contraction may be a result of a change in extrinsic factors influencing the birds' physical ability or predisposition to breed in more northerly areas it once occupied. Conversely, the range contraction may be due to a change in local habitat features (i.e., vegetation structure) such that cues necessary for second-order selection are lacking; or, if cues for habitat selection are present and buff-breasted flycatchers inhabit the area, the vegetation structure and floristics may not provide key resources necessary for survival and reproduction, so that the population does not persist. This hypothesized change in vegetation structure and floristics may have affected any of several factors that may limit the current population of the buff-breasted flycatcher in Arizona.

STUDY AREA

We conducted the study in the Chiricahua (Cochise County), Rincon (Pima County), and Santa Catalina (Pima County) mountains, in southeastern Arizona. These ranges were primarily north-south oriented, separated by broad flat basins of about 900-1200 m in elevation. All ranges rose above 2590 m in elevation. Areas surveyed for buff-breasted flycatchers ranged from 1550-2750 m in elevation. Regionally, the climate in southeastern Arizona was semiarid, with bimodal annual precipitation. About half of the 37-63 cm of annual precipitation fell in July and August, with most of the rest falling from mid-November to mid-April. May was the driest month. At Fort Huachuca (elev 1420 m), average January temperatures were 7.9°C (average daily maximum and minimum: 14.7 and 1.2°C), and average July temperatures were 25.3°C (average daily maximum and minimum: 38.4 and 19.1°C). At higher elevations in the Huachucas average January and July temperatures were 4.4 and 18.3°C, respectively (Sellers and Hill 1974). Biotic communities were primarily Madrean montane coniferous forest and Madrean evergreen forest and woodland (Brown et al. 1979). Streambeds (containing perennial, seasonal, or intermittent water) were intermittently lined by deciduous trees such as sycamore (Platanus wrightii), ash (Fraxinus velutina), walnut (Juglans major) and willow (Salix spp.). Trees in canyon bottoms included chihuahua pine (Pinus leiophyllus), apache pine (P. englemannii), alligator juniper (Juniperus deppeanna) and oak (Quercus spp.). Higher on the canyon sides oaks, junipers, and Mexican pinion pines (P. cembroides) dominated.

METHODS

(For a more detailed description of methods, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004)

Surveys --To accomplish our first objective (determining location and size of breeding populations of buff-breasted flycatchers in southeastern Arizona mountains), we conducted surveys for buff-breasted flycatchers. Survey sites were selected by first determining, through examination of the literature, the historic distribution of the buff-breasted flycatcher. Phillips et al. (1964) indicated that the birds once occupied several mountain ranges in the southeast corner of the state, namely the Santa Catalina, Rincon, Santa Rita, Chiricahua, and Huachuca mountains. Buff-breasted flycatchers have recently been reported from the Whetstone Mountains (T. Corman, Arizona Game and Fish Dept., pers. commun.). We surveyed all locations in these mountain ranges with published or unpublished reports of buff-breasted flycatcher occurrence, except Miller Canyon in the Huachuca Mountains. In 1996 we surveyed 12 canyons with records of buff-breasted flycatcher occurrence, and 15 canyons selected randomly in the Santa Catalina, Rincon and Chiricahua ranges (Table 1).

Surveys were conducted by slowly walking specified routes (usually major drainages) within potential habitat (forested or woodland areas above 1600 m elevation in mountain ranges with records of buff-breasted flycatcher occurrence), listening and looking for buff-breasted flycatchers. Approximately every 200 m the observer stopped and broadcast calls of the species for 30 seconds, followed by a one-minute pause to listen for a response, followed by another 30 second broadcast if no response was detected. The broadcast ceased upon response by a bird. This technique agrees with guidelines suggested by Johnson et al. (1981). We conducted surveys once in each selected canyon, during the months of May and June. Surveys began within 30 min. of sunrise and lasted up to about 4 hours. To determine trends in numbers of buff-breasted flycatchers in areas that were occupied in 1980-1983 and in 1995-1996, we examined maps depicting the areas surveyed and monitored by Bowers (1983, unpublished ms.) and recorded the number of buff-breasted flycatchers we found in those areas. We compared the maximum annual count of buff-breasted flycatchers made by Bowers in these areas with the numbers that we found in 1995 or 1996 with a paired T-test.

Habitat measurement --To accomplish our second objective (i.e., to determine whether or not there is a difference between areas within a canyon used by buff-breasted flycatchers and the areas available to the birds, and the nature of that difference), we first determined used areas. A used area was any area that was occupied by a buff-breasted flycatcher during the breeding season, regardless of behavior. In 1996 we recorded 1-4 locations for a given buff-breasted flycatcher in conjunction with monitoring the bird's reproductive activity (approximately every 5 days). Observations were made at different times of day on different days. The place where the bird was first detected was recorded as the first location, and subsequent locations were recorded at 10-min intervals. Six weeks after the median start date of construction of nests that were thought to be first nesting attempts of the season, we constructed a minimum convex polygon from the set of locations. From the center of the polygon, we placed vegetation sampling plots at 0, 120, and 240 degrees, at randomly selected distances such that all vegetation sampling plots were enclosed completely within the polygon, and the plots did not overlap.

On these sampling plots we sampled vegetation and other habitat variables using a method based on that proposed by Noon (1981). We sampled within a circle of 15 m radius. Trees (woody perennial plants >2 m in height and >10 cm dbh) in the circle were counted, by species and dbh class. We estimated height and vigor, and measured dbh, of the tallest specimen of each tree species in the circle. We counted the number of shrub species in the circle. We recorded vegetative cover intersecting 29 vertical point-intercept lines, in 5 height categories. We recorded slope, slope position, aspect, distance to the riparian zone, and distance to the nearest opening. Variables measured are defined in Appendix A. We estimated UTM coordinates of each used area.

We also recorded the above measurements at 30 systematically selected points within 4 canyons occupied by buff-breasted flycatchers, to characterize available potential habitat.

To address our third objective we recorded all of the habitat measurements stated above for used vs. available areas at vegetation sampling plots centered on the nest sites. In addition, we recorded nest tree species, nest tree height, nest height, nest tree dbh, compass direction of nest from trunk, distance of nest from trunk, distance from the rim of the nest up to vegetation, distance of nest from outer edge of vegetation of the nest tree, and diameter of the supporting branch.

To address objectives 4 and 5 we re-visited 24 canyons (10 in the Huachucas and 14 in the Chiricahuas) in August 1996 that we had previously surveyed for buff-breasted flycatchers. These 24 canyons all contained some Madrean pine-oak forest or Madrean oak-pine woodland. We recorded vegetation type after Brown et al. (1979), structural stage, and estimated canopy coverage after Reynolds et al. (1992) of any forest vegetation type within a 100-m radius of 514 points at 200-m intervals along the survey routes. We estimated width perpendicular to the transect line of the forested vegetation within 100 m of the points. The location of these points approximates the location of the points at which buff-breasted flycatcher calls were broadcast during the surveys.

Reproductive success --To address objective 6 we estimated reproductive success in 1996 in Cave Creek, Pinery, Rucker, and West Turkey Creek canyons in the Chiricahua Mountains. Following the morning surveys described above, we returned to observe buff-breasted flycatchers at locations where the species was detected. In a 30-minute observation period, we noted the number of buff-breasted flycatchers observed and the following behaviors when they occurred: presence, singing, pairing, carrying of nest material, nest construction, occupation of a nest, carrying of food, carrying of fecal sacs, and presence of at least 1 fledgling. We conducted 30-min observations once every 4-8 days for each used area established. To quantify breeding success while minimizing disturbance to the birds, we calculated an index of reproductive activity (Vickery et al. 1992). With this method, birds are assigned a rank corresponding with a degree of reproductive success, based on easily observable behaviors. Ranks are as follows:

1. occupation of a territory for the length of time required to form a pair, build a nest, lay and

incubate a clutch, and fledge young. For buff-breasted flycatchers this time period is about eight weeks (Bowers 1994).

2. pair formation
3. nest building, egg laying, or incubation
4. presence of nestlings
5. fledging
6. evidence of a second nesting attempt, after successful fledging in the first attempt.
7. evidence of fledging success in first and second nesting attempts.

We monitored activity at nests found in the course of observing buff-breasted flycatcher behavior at used areas. One nest in 1996 was sufficiently low and free of overhanging vegetation for us to check the contents for evidence of cowbird parasitism. We attached a mirror to a telescoping pole 4.7 m long, and checked the contents of this nest.

ANALYSES

We used logistic regression (LR) to compare used areas to availability plots and used areas to nest sites (objectives 2 and 3). As a multivariate statistical technique, LR examines the effect of several independent variables in combination (For a more detailed justification of logistic regression, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004).

To reduce the number of variables used in this analysis to a useful subset, we first eliminated variables that occurred in <10% of the sampling plots. We then compared the 2 groups with Mann-Whitney U-tests on each variable, and eliminated those that did not show a significant difference between the 2 groups. We then checked the remaining variables for intercorrelation. Of a correlated pair of variables ($\underline{R} > 0.8$) we eliminated the variable that showed the less significant difference in the Mann-Whitney U-test. We performed separate LR analyses for each of the 8 canyons and each of the 2 mountain ranges in which we measured buff-breasted flycatcher habitat, and for both mountain ranges combined, resulting in 12 models. We performed separate analyses to compare used to available areas, and used areas to nest sites.

Because our original variable screening procedures left many variables that, due to their small between-group differences were probably not biologically significant (though they were statistically significant) we listed all variables selected in any of the 12 used-vs.-available models and selected a subset that met the following criteria: variables expressed as % cover showed $\geq$5% cover and means differing by $\geq$5% between groups (or standard deviations differing by >50%), variables expressed as counts of trees or shrub species showed >10% difference in means between groups (or standard deviations differing by >50%), variables measuring tree vigor showed a between-group difference in means >20%, variables expressed as probability of presence of a shrub species showed >50% between-group differences, variables representing dbh of the tallest specimen of a tree species in the plot showed a between-group difference in mean dbh >10 cm (and occurred in >20% of the plots) and variables representing the height of the tallest specimen of a tree species in the plot showed a mean height difference >3 m (and occurred in >20% of the plots). We entered this set of variables into another LR procedure using the pooled data from all canyons sampled. We repeated this selection and LR procedure with the 12 nest site vs. used area models, the successful nest site-vs.-unsuccessful nest site model, the successful used area-vs.-unsuccessful used area model, to create a model for each of these comparisons.

To address objectives 3 and 4 we tested vegetation type, forest structural stage, canopy cover category, forest width, and these 4 variables combined, for association with buff-breasted flycatcher presence at survey broadcast points using χ^2 contingency tables. We tested for these associations twice: once including all vegetation types recorded, and once including only vegetation types that included pines (Madrean pine forest, Madrean pine-oak forest, Madrean pine-juniper forest, and Madrean oak-pine woodland).

To identify habitat characteristics associated with successful reproduction (objective 6) We performed LR analyses comparing successful to unsuccessful nests, and successful to unsuccessful used areas. We performed multiple regressions, with stepwise variable entry, of reproductive success rank on habitat variables of used areas, using the same criteria to select regressors that we used in the initial canyon-specific LR procedures.

RESULTS

Surveys

Buff-breasted flycatchers found in 1996--In the course of the surveys, we counted 44 buff-breasted flycatchers. We detected buff-breasted flycatchers in Cave Creek (middle fork), Pinery, Rucker, West Turkey Creek, Saulsbury, Ward, Pine, Red Rock, Bear, and East Turkey Creek canyons in the Chiricahua Mountains, and Sycamore Canyon in the Santa Catalina Mountains (Table 1). Assuming that the buff-breasted flycatcher call broadcast during the survey was audible within 100 m on either side of the survey transect, we surveyed 2004 ha in the Chiricahua Mountains, 588 ha in the Santa Catalina Mountains, and 80 ha in the Rincon Mountains, for a total of 2672 ha surveyed.

While conducting behavioral observations we found additional buff-breasted flycatchers in Cave Creek (2 additional birds), Pinery (6 additional birds), Rucker (2 additional birds) and West Turkey Creek (including Saulsbury and Ward canyons) (10 additional birds) in the Chiricahuas, bringing the total number of adult buff-breasted flycatchers detected in 1996 to 54 (Table 2).

We found few buff-breasted flycatchers in canyons from which they had not previously been reported. We found 1 pair in Sycamore Canyon in the Santa Catalina Mountains, 1 pair and an undetermined number of juveniles in Bear Canyon, Chiricahua Mountains, and 1 probable sighting in East Turkey Creek, Chiricahua Mountains. In addition, we found buff-breasted flycatchers in formerly or presently occupied canyons, but in areas of the canyon from which the birds were previously unknown and probably not looked for. We found 1 individual in Pine Canyon, Chiricahua Mountains, at the junction with the Rattlesnake Trail, far from the junction of Pine and Hoovey canyons. We found 7 buff-breasted flycatchers and a nest with nestlings in Rucker Canyon 4-5 km downstream from Rucker Lake. Locations of all buff-breasted flycatchers detected are mapped and their UTM coordinates listed in a separate document (Locations of buff-breasted flycatchers encountered in the course of field investigations, Arizona Game and Fish Department Heritage Fund Project No. I94004).

Comparisons with previous findings on distribution and abundance --We have few records of locations where researchers or birders have looked specifically for buff-breasted flycatchers and reported their absence, so it is difficult to assess the significance of our observations of birds in areas from which they have not been previously reported. However, the negative change (previously occupied areas that we found unoccupied) that we observed was 56%, while the positive change (new buff-breasted flycatcher locations found / areas surveyed for which previous buff-breasted flycatcher occupancy had not been reported) was 12.5%. In most of the canyons surveyed and subsequently monitored for buff-breasted flycatcher reproduction by Bowers (1983, unpublished ms.) we found more birds within his study areas in our surveys and monitoring than he did. Maximum number of birds found by Bowers in any of the 4 years that he observed in a given canyon is shown in parentheses: Within Bowers' study areas, we found 17 birds in Carr Canyon (9), 20 birds in Sawmill Canyon (11), 4 birds in Scotia Canyon (6), 4 birds in Sunnyside Canyon (2), 6 birds in Cave Creek Canyon (2), 8 birds in Rucker Canyon (1), and 14 birds in West Turkey Creek Canyon (5). A paired T-test indicates that we found significantly more birds in these locations ($\underline{P} = 0.015$) Bowers did not observe in every canyon in each year of his study.

In 15 of the 25 areas with prior buff-breasted flycatcher records that we surveyed, we did not find the species (Table 3). Twelve of the canyons that we surveyed in 1995-1996 were inhabited by buff-breasted flycatchers at some time between 1980-1983 (Bowers and Dunning 1994). We found buff-breasted flycatchers in all but 5 of these canyons: East Whitetail, South Fork Cave Creek, Rose, Garden, and Rock Spring. In 2 of these 5 canyons (East Whitetail and South Fork Cave Creek canyons, Chiricahua Mountains), Bowers and Dunning found only 1 bird in 1 year. These canyons were probably not host to long-term breeding populations in 1980-1983. In the Chiricahua Mountains in Pine Canyon (at the intersection with Hoovey Canyon), H. Snyder (pers. commun.) reported a singing buff-breasted flycatcher apparently holding a territory in 1994, but we did not find the species there in 1996. This area looked like particularly good potential buff-breasted flycatcher habitat.

We found 20 buff-breasted flycatchers during surveys in canyons that were subsequently monitored for nesting activity, and 32 buff-breasted flycatchers over the entire monitoring period

(14-18 visits distributed over the 3-month breeding season): a difference of 37.5% (Table 2).

Reproductive Success

Used areas --We identified 19 used areas in 1996 and ranked the reproductive success of the buff-breasted flycatchers using them. No areas received a rank of 0 (buff-breasted flycatchers observed, but not for a long enough period of time to carry out a successful nesting attempt), No areas received a rank of 1 (territorial buff-breasted flycatcher present long enough to carry out a successful nesting attempt, but no pairing observed), no areas received a rank of 2 (territorial pair of buff-breasted flycatchers present for a sufficient period of time to carry out a successful nesting attempt, but no evidence of nesting observed), 3 areas received a rank of 3 (evidence of nesting observed, but no evidence of nestlings observed), 4 areas received a rank of 4 (evidence of presence of nestlings observed, but no evidence of fledging), 12 areas received a rank of 5 (evidence of fledging observed, but no evidence of a subsequent nesting attempt), no areas received a rank of 6 (evidence of successful fledging in a first nesting attempt, and evidence that the pair made a subsequent nesting attempt), and no areas received a rank of 7 (evidence of successful fledging in more than 1 nesting attempt) (Table 4). All 19 areas received a rank $\geq$3 (indicating presence of a breeding pair) in 1996, 12 (63%) received a rank $\geq$5 (indicating successful fledging).

Nests.--In 1996 we found 26 nests, built by 19 pairs. Twelve nests (46%) successfully fledged young, 12 nests (42%) are known to have failed, and the outcome of 2 nests was unknown. Median fledging date was between 9 July and 14 July. Eight nests were known to be subsequent attempts after failure of an earlier attempt. No subsequent attempts after a successful first attempt were observed in 1996. We found 3 nests (2 successful) made by 3 pairs in Cave Creek Canyon, 7 nests (3 successes) made by 5 pairs in Pinery Canyon, 6 nests (3 successes and 1 unknown) made by 4 pairs in Rucker Canyon, and 11 nests (4 successes and 1 unknown) built by 7 pairs in West Turkey Creek Canyon. The first nest that we monitored in 1996 was found (while under construction) on 5 May (though nest construction was observed on 13 April 1996 in Sawmill Canyon, Huachuca Mountains). The first fledglings of 1996 were seen on 9 June.

At 20 of the 36 failed nests observed in 1995 and 1996, we found evidence of probable jay predation (usually the remains of the nest on the ground). Of these 20, 3 were depredated with young in the nest, 7 were under incubation, 8 were depredated after construction was complete but before incubation was observed, and 2 were found destroyed before construction was known to be complete. Two nests were probably destroyed by severe weather. One nest was destroyed when the nest tree was cut during campground maintenance-related tree cutting. We have no evidence for cause of failure of the remaining 13 failed nests, but cannot rule out predation.

We examined the contents of 1 nest in 1996. This nest (Pinery Canyon # 3) contained 3 nestlings. We found no cowbird eggs or young in buff-breasted flycatcher nests. In addition, we saw adult buff-breasted flycatchers feeding 12 broods of fledglings from nests the contents of which we did not check, and saw no fledgling cowbirds. Distance up to nearest vegetation over the rim of the nest averaged 5.6 cm, and ranged from 3-20 cm. In 1996, 18 (72%) of the nests we found had vegetation $\leq$5 cm above the rim of the nest.

Habitat Characteristics

Coarse-grained variable analyses. --At 574 survey broadcast points, in 26 canyons, 13 different vegetation types were recorded. We recorded widths ranging from 50 m to 2000 m of the forest patch containing the survey transect. Not every 50-m interval in this 1950-m interval was encountered: we recorded 14 different width categories of the 20 possible. We found that buff-breasted flycatchers occurred more frequently than expected in the Madrean pine-oak forest vegetation type (Table 5), in patches >150 m wide (Table 6), under moderately open canopy cover (Table 7), and in mid-aged to old forest structural stages (Table 8). All of the aforementioned χ^2 tests, except that testing for association between canopy cover category and buff-breasted flycatcher presence, had >10% of their cells with frequency <5. Buff-breasted flycatcher numbers were not significantly different from expected by mountain range.

Used vs. available. --The LR procedure selected 17 variables for inclusion in the used vs. available model (Table 9). The model correctly classified 94.4% of the used area plots, 98.3% of the available sampling plots, and 97.1% of all of the sampling plots. The 4 variables with the highest partial correlation coefficients were % oak cover 0-1 m, no. of trees 20-30 cm dbh, % cover alligator juniper, 2-5 m, and shrub Arizona grape present. Median %oak cover 0-1 m in used areas was 0.0% $\pm$ 0.67%, and 0.0% $\pm$ 1.2% in available areas. Median number of trees 20-30 cm dbh was 9 $\pm$ 3.8 in used areas, and 6 $\pm$ 3.8 in available areas. Median % cover alligator juniper 2-5 m was 3.0 $\pm$ 3.5 in used areas, and 1 $\pm$ 2.3 in available areas. Median probability of occurrence of Arizona grape in used areas was 1 $\pm$ 0.49, whereas in available areas it was 0.0 $\pm$ 0.49 (Tables 9-11). Used areas were characterized by an open-canopy forest of chihuahua and/or apache pine with an open understory of oak, on a relatively flat area. For a more broadly applicable LR model describing differences between used and available areas, incorporating data from the Chiricahua and Huachuca mountains, in 1995 and 1996, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004.

Nest sites vs. used areas --The LR procedure selected 11 variables accounting for differences between nest sites and used areas. The four most important variables were number of oaks 10-20 cm dbh (3.5 ± 6.9 in used areas, 4.0 ± 6.5 at nest sites)(Table 12), number of shrub species (10 ± 3.6 in used areas, 7 ± 3.5 at nest sites), dbh of tallest sycamore (35 ± 22.4 cm in used areas, 66 ± 25 cm at nest sites), and % cover leaf litter (22 ± 5.5 in used areas, 24.5 ± 3.5 at nest sites). For a LR model describing differences between used areas and nest sites, incorporating data from the Chiricahua and Huachuca mountains, in 1995 and 1996, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004.

Characteristics associated with successful reproduction --Sample sizes were insufficient in 1996 alone to determine a relationship between habitat variables and reproductive success. For LR models describing these relationships, and a multiple regression model examining the relationship between habitat variables and reproductive success rank, incorporating data from Chiricahua and Huachuca mountains in 1995 and 1996, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004.

For information regarding canyon-specific logistic regression models, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004.

DISCUSSION

Abundance and Distribution

We found some evidence that even within the last 20 years, some small populations (isolated groups of 1-2 breeding pairs) of buff-breasted flycatchers have disappeared from the aforementioned mountain ranges. Either these small populations have indeed disappeared (perhaps only temporarily), or our survey technique is not effective. A comparison of the numbers of birds detected during surveys in canyons where we subsequently monitored birds, and the number of birds we found while monitoring, suggests that the surveys were reasonably effective (Table 2). A comparison of the numbers of buff-breasted flycatchers detected on surveys with the number found in subsequent monitoring suggests that surveys detect about 30% fewer birds than are present in the surveyed area, but records suggest that surveys more accurately assess the number of breeding pairs in the area. On many occasions, only 1 buff-breasted flycatcher responded to a survey broadcast, but in subsequent monitoring we found the area to be occupied by a breeding pair. The female of the pair may not have responded because she was incubating or laying eggs and did not wish to draw attention to the nest. This postulated sex-dependent difference in responsiveness may be responsible for the difference in numbers of birds detected on the survey and in subsequent monitoring. If so, our survey technique was not as inferior to intensive monitoring as the difference suggests. In addition, Bowers also used a tape-broadcast survey technique, so our failure to detect buff-breasted flycatchers in 1996 in the areas in which he found them in 1980-83 is probably not due to difference in survey technique. Observations of buff-breasted flycatchers in other areas (i.e., the junction of Pine and Hoovey canyons, Sprung Spring) were made by birders who were not specifically searching for this species, and were not using taped calls. It might be argued that taped calls actually repelled some buff-breasted flycatchers, but we have no evidence that this is the case. Buff-breasted flycatchers seemed quite responsive to broadcasts of taped calls.

Though there is evidence that some small populations have disappeared in the last 15 years, there is also evidence that in areas where they still occur, buff-breasted flycatchers are more abundant than they were when Bowers studied this species 15 years ago. In all 4 canyons in which we and Bowers both found the species, we found more birds than he did. These differences may reflect inter-observer variability rather than actual differences in buff-breasted flycatcher abundance.

These conflicting lines of evidence of buff-breasted flycatcher population trends, and the paucity of specific survey data on buff-breasted flycatchers point out the need for continued monitoring of this species. Studies have shown that bird populations are quite dynamic. Wilcove and Terborgh (1984) developed the hypothesis that populations at the edge of a species' range (like those of buff-breasted flycatchers in Arizona) should be the first to decrease when overall numbers of the species fall, before a decline is observed in populations toward the core of a species' range. These small populations of breeding buff-breasted flycatchers may persist over the long term due to a "rescue effect" (i.e.,disappear temporarily, to be re-established in subsequent years by colonists from other concentrations of birds) (Brown and Kodric-Brown 1977). Our short-term study and that of Bowers and Dunning (1994) taken in conjunction are insufficient to draw conclusions regarding long-term population trends of buff-breasted flycatchers in Arizona. Longer-term surveys are needed to determine whether the decline in Arizona buff-breasted flycatcher numbers that began in the early 20th century continues. We (the authors) have surveyed all locations in the Santa Catalina, Rincon, Santa Rita, Huachuca and Chiricahua mountains with published records of buff-breasted flycatcher occurrence, and most, if not all of the locations with unpublished records [except Miller Canyon, which we were reasonably sure was not of major importance to buff-breasted flycatchers. L. Christoferson, who conducted intensive bird studies in Miller Canyon in the Huachuca Mountains in 1994, found no buff-breasted flycatchers there. Buff-breasted flycatchers were not detected in neotropical migratory bird surveys conducted in Miller Canyon in 1994-1995 (L. Christoferson, L. Hall, J. Martin, M. Morrison and R. Mannan. 1996. unpublished ms.)]. Our survey results constitute a baseline from which to assess future buff-breasted flycatcher population trends. In light of the evidence for a decline in populations in the last 15 years, the need for surveys and monitoring to maintain current knowledge of buff-breasted flycatcher numbers and distribution has become more important.

We strongly re-affirmed that the buff-breasted flycatcher is discontinuous and patchy in distribution. Swarth (1914) states that the buff-breasted flycatcher is "nowhere very common . . . very locally distributed--thus it may be fairly common in one canyon and almost unknown in an adjoining one." Marshall (1957) writes that "The environmental conditions of the few places of record are duplicated within practically every mountain range studied, yet the species shows erratic and unpredictable occurrence." S. M. Russell (pers. commun.) reiterates that the species' distribution is spotty and unpredictable, and some apparently suitable habitat is unoccupied. Swarth's observations date from the period prior to the buff-breasted flycatcher's disappearance from the White Mountains, and suggest that this pattern is not a recent phenomenon. Both Marshall and Russell were referring to the buff-breasted flycatcher's distribution in Sonora, Mexico as well as in Arizona, so the species shows this distributional pattern at least 250 km south of its largest concentrations in Arizona. Perhaps this species is, and always has been, naturally rare, for reasons not well understood. Unfortunately, data from central and southern Mexico and Central America are almost entirely lacking for this species.

Habitat Characteristics

Our LR analyses identified habitat characteristics that differ between buff-breasted flycatcher home ranges (used areas) and available areas. One of the more important (indicated by relatively high R value) variables chosen was distance to opening. Buff-breasted flycatchers' used areas tended to be farther from an area without vegetation over 10 m high than were available areas. Proximity to an edge is correlated with increased nest predation rates in some passerine birds (Gates and Gysel 1978). The positive correlation between use by buff-breasted flycatchers and distance to opening may be due to increased nest predation rates at the edge of the patch of pine forest. Buff-breasted flycatcher use was negatively associated with oak cover 0-1 m. This corroborates annecdotal observations (Lusk 1901, Swarth 1904, Willard 1923, and Bent 1942) associating buff-breasted flycatchers with open pine forests.

Important differences between nest sites and used areas included number of shrub species (fewer in nest sites than used areas), number of oak trees 10-20 cm dbh (fewer in nest sites than used areas), % cover of small dead branches 0-1 m (less in nest sites than used areas) and number of Mexican white pines (fewer in nest sites than used areas). White pines tended to retain branches low on the trunk, and thus contribute to foliage cover in the forest understory. All of these variables suggest less vegetative cover in the understory at nest sites than used areas. Because nest sites were within areas used by the birds, nest site and used area sampling plots could and sometimes did overlap. We may have missed differences between nest sites and used areas, and the differences we found may be more pronounced than our figures indicate, because of this overlap.

The most important finding of our analysis of coarse-grained variables at survey broadcast points was that buff-breasted flycatchers prefer wider areas of pine forest. When we restricted our analysis to vegetation types with a pine component (Madrean pine-oak forest, Madrean pine forest, Madrean pine-juniper forest, and Madrean oak-pine woodland) we found that buff-breasted flycatchers occurred more frequently than expected in forest patches >150 m wide.

For a discussion of factors possibly limiting buff-breasted flycatcher distribution and abundance, and recommendations for research and management of buff-breasted flycatchers, incorporating findings from 1995 and 1996 in the Chiricahua and Huachuca mountains, see Final Report, Arizona Game and Fish Department Heritage Fund Project No. I94004.

ACKNOWLEDGMENTS

This research was funded by the Arizona Game and Fish Department Heritage Fund, grant no. I96007. We would also like to thank Sheridan Stone and Steve Schacht for logistical assistance, Helen and Noel Snyder for accommodations, Linnea Hall, Amy Antonioli, Hillary Heard, Trish Cutler, Dave Griffin, Chris Kirkpatrick, Scott McCarthy, Justin White and Suellen Lynn for field assistance.

LITERATURE CITED

Arizona Game and Fish Dept. 1988. Draft List of Wildlife of Special Concern in Arizona. Arizona Game and Fish Dept. publications. Phoenix, Arizona. 32 pp.

Bent, A. C. 1942. Life histories of North American flycatchers, larks, swallows, and their allies. Smithsonian Institution, Washington, D.C. 555 pp.

Bowers, R. K. Jr. 1983. Life history and distribution of the buff-breasted flycatcher (Empidonax fulvifrons) in Arizona. Unpublished ms. 15 pp.

------ and J. B. Dunning 1984. Nest parasitism by cowbirds on buff-breasted flycatchers, with comments on nest site selection. Wilson Bull. 96(4):718-719

------- and J. B. Dunning 1994. Buff-breasted Flycatcher (Empidonax fulvifrons). In The Birds of North America, No.125(A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Brandt, H. 1951. Arizona and its bird life. The bird research foundation, Cleveland Ohio.

Brown, D. E., C. H. Lowe and C. P. Pase. 1979. A digitized classification system for the biotic communities of North America, with community (series) and association examples for the southwest. J. Arizona-Nevada Acad. Sci. 14:(suppl. III)

Brown, J. H., and A. Kodric-Brown. 1977. Turnover rates in insular biogeography: Effects of immigration on extinction. Ecology 58:445-449.

Gates, J. E. And L. W. Gysel. 1978. Avian nest dispersion and fledgling success in field-forest ecotones. Ecology 59:871-883.

Howard, O. W. 1899. Some of the summer flycatchers of Arizona. Condor 1:103-107.

Hunter, W.C., M.F. Carter, D. N. Pashley, and K. Barker. 1992. The Partners in Flight prioritization scheme. In D.M. Finch and P.W. Stengel, eds. Status and Management of Neotropical Migratory Birds. Gen. Tech. Rept. RM-299. Fort Collins, CO: U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 422 pp.

Hutto, R. L. 1985. Habitat selection by nonbreeding, migratory land birds. Pages 455-476 in M. L. Cody, ed. Habitat selection in birds. Academic Press.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71

Johnson, R. R., B. T. Brown, L. T. Haight, and J. M. Simpson. 1981. Playback recordings as a special avian census technique. In C. J. Ralph and J. M. Scott, eds. Estimating numbers of terrestrial birds. Studies in Avian Biology No. 6 Cooper Ornithological Society.

Kelly, J. P. 1993. The effect of nest predation on habitat selection by dusky flycatchers in limber pine-juniper woodland. Condor 95:83-93

Knopf, F. L., and J. A. Sedgewick. 1992. An experimental study of nest site selection by yellow warblers. Condor 94:734-742

Lusk, R. D. 1901. In the summer home of the buff-breasted flycatcher. Condor 4:38-41

Marshall, J. T. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Pacific Coast Avifauna no. 32. Cooper Ornithol. Soc., Berkeley, Cal. 125 pp.

Martin, T. E., and J. J. Roper. 1988. Nest predation and nest site selection in a western population of the hermit thrush. Condor 90:51-57.

Noon, B. R. 1981. Techniques for sampling avian habitats. Pages 42-51 in D. E. Capen, ed., The use of multivariate statistics in the study of wildlife habitat. U.S. For. Serv. Gen. Tech. Rep. RM-87.

Norment, C. J. 1993. Nest site characteristics and nest predation in Harris' sparrows and white-crowned sparrows in the Northwest Territories, Canada. Auk 110:769-777

Phillips, A. R., J. Marshall, and G. Monson. 1964. The birds of Arizona. Univ. of Arizona Press, Tucson. 220 pp.

Reynolds, R. T. , R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, Jr., G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the Northern Goshawk in the Southwestern United States. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. USDA Forest Service Gen. Tech. Rept. RM-217.Here's where I left off.

Robinson, S. K., and R. T. Holmes. 1982. Foraging behavior of forest birds: the relationships among search tactics, diet, and habitat structure. Ecology 63:1918-1931.

_____, _____. 1984. Effects of plant species and foliage structure on the foraging behavior of forest birds. Auk 101:672-684.

_____, J. A. Gryzbowski, S. I. Rothstein, M. C. Brittingham, L. J. Petit and F. R. Thompson. 1993. Management implications of cowbird parasitism on neotropical migrant songbirds. Pp. 93-102 in Finch, D. M., and P. W. Stangel, eds. 1993 Status and management of neotropical migratory birds. 1992 September 21-25; Estes Park, CO. Gen. Tech. Rep. RM-229. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 422 p.

Russell, S. M., and G. Monson. In press. The birds of Sonora. Univ. Arizona Press. Tucson.

Sakai, H. G., and B. R. Noon. 1991. Nest site characteristics of Hammond's and Pacific-slope flycatchers in northwestern California. Condor 93:563-574.

Savage, M. 1991. Structural dynamics of a southwestern pine forest under chronic human influence. Annals of the Association of American Geographers 81:271-279.

Schemnitz, S. D., and M. L. Zornes. 1995. Management practices to benefit Gould's turkeys in the Peloncillo Mountains, New Mexico. Pages 461-464 in DeBano, L. F., P. F. Ffolliott, A. Ortega-Rubio, G. J. Gottfried, R. H. Hamre, and C. B Edminster, tech. coords. Biodiversity and management of the Madrean archipelago: the sky islands of the southwestern United States and northwestern Mexico. 1994 Sept. 19-23; Tucson, AZ. Gen Tech. Rep. RM-GTR-264. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 669 pp.

Sellers, W. D., and R. H. Hill. 1974. Arizona Climate. University of Arizona Press, Tucson.

Swarth, H. S. 1904. Birds of the Huachuca Mountains, Arizona. Pacific Coast Avifauna, no. 4 Cooper Ornithological Club, Hollywood, California.

_____. 1914. A distributional list of the birds of Arizona. Pacific Coast Avifauna no. 10. Cooper Ornithological Club, Hollywood, Calif. 133 pp.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. J. Wildl. Manage. 47:893-901.

Vickery, P. D., M. L. Hunter and J. V. Wells 1992. Use of a new reproductive index to evaluate relationship between habitat quality and breeding success. Auk 109(4):697-705

Wilcove, D. S., and J. W. Terborgh. 1984. Patterns of population decline in birds. Am. Birds 38:10-13.

Willard, F. C. 1923. The buff-breasted flycatcher in the Huachucas. Condor 25(6):189-194

Table 1. Results of buff-breasted flycatcher surveys in Chiricahua, Santa Catalina, and Rincon mountains, 1996.

site	date surveyed	area surveyed (ha)	no. buff-breasted flycatchers
Chiricahua Mts.			
Rucker Cyn.(lower)	96/06/29	72.0	7
Rucker Cyn.(upper)[a]	96/05/05	100.0	6
Cave Crk.(middle fork)[a]	96/05/14	88.0	4
Cave Crk.(south fork)[a]	96/06/06	120.0	0
Bear Cyn.	96/06/08	60.0	3
Red Rock Cyn.[a]	96/06/07	80.0	10
Pine Cyn.[a]	96/05/22	156.0	1
Horseshoe Cyn.	96/06/15	136.0	0
John Long Cyn.	96/05/06	120.0	0
Mormon Ridge Trail	96/06/10	60.0	0
Price Cyn.	96/06/09	100.0	0
East Whitetail Cyn.[a]	96/06/13	124.0	0
Sulphur Draw	96/06/20	140.0	0
East Turkey Creek	96/06/28	112.0	1
Saulsbury Cyn.[a]	96/04/20	40.0	3
Ward Cyn.	96/04/20	48.0	1
West Turkey Creek	96/04/21	84.0	2
Pinery Cyn.(upper)[a]	96/05/12	120.0	1
Pinery Cyn.(lower)	96/06/12	80.0	3
Horsefall Cyn.	96/06/01	48.0	0
Barfoot[a]/Rustler/ Long Parks	96/15/13	116.0	0
Santa Catalina Mountains			
Sycamore Cyn.	96/06/21	60.0	2
Bear Cyn.[a]	96/06/25	36.0	0
Organization Ridge	96/06/20	28.0	0
Spencer Cyn.	96/06/08	60.0	0
Butterfly Trail[a]	96/06/17	52.0	0
Sabino Cyn.	96/06/21	68.0	0
Marshall Gulch	96/06/02	68.0	0
Rose Cyn.[a]	96/05/08	68.0	0
Forest Service Rd. 38	96/06/28	52.0	0
Stratton Cyn.	96/06/17	96.0	0

Rincon Mountains			
Manning Camp[a]/ Fire Loop Trail	96/07/01	80.0	0

[a] Sites from which buff-breasted flycatchers have been reported prior to this study.

Table 2. Numbers of buff-breasted flycatchers detected on surveys and in subsequent monitoring within the area surveyed, Chiricahua mountains, 1996.

canyon	number found on survey	number found during monitoring
Cave Creek Cyn.	4	6
Pinery Cyn.	4	2
Rucker Cyn.	6	8
West Turkey Creek Cyn.	6	16
Total	20	32

Table 3. Areas with records of buff-breasted flycatcher occupation, in which we did not find buff-breasted flycatchers in 1996.

location	date of record	source
Chiricahua Mountains		
South Fork Cave Creek Cyn.	1980	Bowers and Dunning (1994)
East Whitetail Cyn.	1981	Bowers and Dunning (1994)
Barfoot Park	1919-21	Hubbard (1972)
jct. Pine and Hoovey Cyn.	1994	H. Snyder (pers. comm.)
Santa Catalina Mountains		
Rose Cyn.	1980-82	Bowers and Dunning (1994)
Butterfly Trail	?	Davis and Russell (1984)
Bear Cyn.	1971	G. Monson (pers. comm.)
Rincon Mountains		
Manning Camp	1911	Marshall (1956)

[a] Location where Bowers found buff-breasted flycatchers is outside the area we surveyed.

Table 4. Reproductive success ranks associated with areas used by buff-breasted flycatchers, Chiricahua mountains, 1996.

Canyon	used area no.	rank[a]
Cave Creek		
	CC01	5
	CC02	5
	CC03	3
Pinery		
	PY01	3
	PY02	0
	PY03	5
	PY04	4
	PY05	5
	PY06	5
Rucker		
	RU01	5
	RU02	5
	RU03	4
	RU04	5
West Turkey Creek		
	WT01	5
	WT02	5
	WT03	5
	WT04	3
	WT05	5
	WT06	4
	WT07	4

[a] ranks: 1: occupation of territory, 2: pair formation, 3: nest-building and/or egg-laying and/or incubation, 4: nestlings present, 5: successful fledging, 6: second nesting attempt following successful fledging, 7: second brood successfully fledged.

Table 5. Contingency table of buff-breasted flycatcher occurrence by vegetation type[a] at survey points, Huachuca and Chiricahua mountains, 1995-1996.

	BBFL occurrence					
	absent			present		
vegetation type[a]	observed	expected	%	observed	expected	%
Interior manzanita chaparral (1,133.322)	3	3.6	75.0	1	0.4	25.0
Madrean douglas-fir/mixed conifer forest (1,122.611)	87	77.0	100.0	0	9.0	0.0
Madrean oak-pine woodland (1,123.324)	45	44.8	90.0	5	5.2	10.0
Madrean oak woodland (1,123.311 or 1,123.315)	21	20.6	91.3	2	2.4	8.7
Madrean oak-pinion-juniper woodland (1,123.316)	102	90.4	100.0	0	10.6	0.0
Madrean pine forest (1,122.62)	13	11.6	100.0	0	1.4	0.0
Madrean pine-juniper forest (1,122.625)	10	9.9	90.9	1	1.1	9.1
Madrean pine-oak forest (1,122.624)	211	232.8	81.2	49	27.2	18.8
Madrean subalpine coniferous forest (1,121.5)	3	2.7	100.0	0	0.3	0.0
Relict cypress forest (1,123.521)	9	9.0	90.0	1	1.0	10.0
Riparian deciduous forest (1,223.222)	10	6.3	100.0	0	0.7	0.0

Chi-Square	Value	DF	Significance
Pearson	48.90497	13	0.00000
Likelihood Ratio	66.24633	13	0.00000

Cells with expected frequency < 5 : 15 of 28 (53.6%)
minimum expected frequency = .105

[a] after Brown, Lowe and Pase (1982).

Table 6. Contingency table of buff-breasted flycatcher occurrence by width of forest patch at survey points, Huachuca and Chiricahua mountains, 1995-1996.

	BBFL occurrence					
	absent			present		
width	observed	expected	%	observed	expected	%
<50 m	118	111.9	94.4	7	13.1	5.6
50-100 m	99	95.8	92.5	8	11.2	7.5
100-150 m	60	58.2	92.3	5	6.8	7.7
150-200 m	42	43.0	87.5	6	5.0	12.5
200-250 m	19	24.2	70.4	8	2.8	29.6
250-300 m	17	24.2	63.0	10	2.8	37.0
300-350 m	5	8.1	66.7	3	0.9	33.3
350-400 m	9	11.6	69.2	4	1.4	30.8
400-450 m	3	3.6	75.0	1	0.4	25.0
450-500 m	9	9.9	81.8	2	1.1	18.2
700-750 m	0	0.9	0.0	1	0.1	100.0
950-1000 m	47	43.9	95.9	2	5.1	4.1
1200-1250 m	0	0.9	0.0	1	0.1	100.0
1950-2000 m	85	77.9	97.7	2	9.1	2.3

Chi-Square	Value	DF	Significance
Pearson	73.70539	13	.00000
Likelihood Ratio	55.63084	13	.00000

Minimum Expected Frequency = 0.105
Cells with Expected Frequency < 5 : 11 of 28 (39.3%)

Table 7. Contingency table of buff-breasted flycatcher occurrence by canopy cover category at survey points, Huachuca and Chiricahua mountains, 1995-1996.

	BBFL occurrence					
	absent			present		
canopy cover	observed	expected	%	observed	expected	%
no vegetation > 10 m	106	95.8	99.1	1	11.2	0.9
open canopy: 0-30% cover	134	128.9	93.8	9	15.1	6.3
semi-open canopy: 30-60% cover	201	223.9	80.4	49	26.1	19.6
closed canopy: > 60% cover	72	65.4	98.6	1	7.6	1.4

Chi-square	Value	DF	Significance
Pearson	41.85507	3	.00000
Likelihood Ratio	47.85272	3	.00000

minimum expected frequency = 7.631

Table 8. Contingency table of buff-breasted flycatcher occurrence by vegetation structural stage at survey points, Huachuca and Chiricahua mountains, 1995-1996.

	BBFL occurrence					
	absent			present		
structural stage	observed	expected	%	observed	expected	%
not coniferous forest (0-2.54 cm dbh)	91	82.4	98.9	1	9.6	1.1
seedling-sapling (2.54-12.7 cm dbh)	18	17.9	90.0	2	2.1	10.0
young forest (12.7- 30.48 cm dbh)	41	38.5	95.3	2	4.5	4.7
mid-age forest (30.48- 45.72 cm dbh)	133	137.9	96.4	21	16.1	13.6
mature forest (45.72 - 60.96 cm dbh)	86	94.0	81.9	19	11.0	18.1
old forest (>60.96 cm dbh)	145	143.3	90.6	15	16.7	9.4

Chi-square	Value	DF	Significance
Pearson	18.59015	5	0.00229
Likelihood Ratio	22.74278	5	0.00038
Mantel-Haenszel	7.93592	1	0.00485

Cells with expected frequency < 5 : 2 of 12 (16.7%)
minimum expected frequency = 2.091

Table 9. Variables, parameters, and classification results of logistic regression model, areas used by buff-breasted flycatchers vs. available areas, Chiricahua Mountains, 1996.

Variable	Coefficient	R	Classification Results	
			group	% correct
% cover coffeeberry, 1-2 m	13.8802	0.091	used	94.44%
% cover oak, 0-1 m	-14.4571	-0.112	available	98.33%
% total live cover, 0-1 m	2.3497	0.105	overall	97.13%
no. of trees 20-30 cm dbh	3.2005	0.115		
% cover alligator juniper, 2-5 m	2.9265	0.111		
% cover douglas-fir, 1-2 m	-20.1145	0.000		
% cover apache and chihuahua pine, 2-5 m	4.8438	0.103		
no. of apache and chihuahua pines, 50-60 cm dbh	7.1033	0.087		
% cover leaf litter	-1.8030	-0.091		
vigor of tallest netleaf oak	11.7141	0.068		
no. of apache and chihuahua pines, 40-50 cm dbh	7.2625	0.109		
vigor of tallest white pine	6.3947	0.096		
shrub manzanita present	-32.8210	0.000		
shrub Arizona grape present	-10.6783	-0.113		
shrub Arizona creeper present	-17.5050	0.000		
shrub agave present	11.9342	0.091		

Model Chi-Square = 196.579 (P = 0.0000)
Goodness of Fit = 17.369

Table 10. Descriptive statistics of variables used to build logistic regression models of buff-breasted flycatcher habitat: values for available areas, Chiricahua Mountains, 1996.

variable	mean	standard deviation	range	skewness	kurtosis	significance of Lilliefors
% cover coffeeberry, 1-2 m	0.04	0.24	2.0	5.3	43.7	0.0000
% cover oak, 0-1 m	0.92	1.20	4.0	1.1	0.1	0.0000
% total live cover, 0-1 m	9.2	5.8	27.0	0.87	0.61	0.0031
no. of trees 20-30 cm dbh	6.5	3.8	17.0	0.44	-0.46	0.0012
% cover alligator juniper, 2-5 m	1.8	2.4	10.0	1.4	1.9	0.0000
% cover douglas-fir, 1-2 m	0.3	0.7	4.0	2.9	9.0	0.0000
% cover apache and chihuahua pine, 2-5 m	0.8	1.1	7.0	2.2	7.4	0.0000
no. of apache and chihuahua pines, 50-60 cm dbh	0.4	0.8	4.0	2.2	5.2	0.0000
% cover leaf litter	21.2	5.2	24.0	-0.9	0.5	0.0000
vigor of tallest netleaf oak	2.5	1.0	3.0	-2.5	6.3	0.0053
no. of apache and chihuahua pines, 40-50 cm dbh	0.65	0.9	4.0	1.4	1.5	0.0000
vigor of tallest white pine	3.5	0.8	3.0	-0.3	-0.3	0.0188
shrub manzanita present .	0.02	0.16	1.0	6.2	36.6	0.0000
shrub Arizona grape present	0.4	0.5	1.0	0.4	-1.8	0.0000
shrub Arizona creeper present	0.02	0.15	1.0	6.2	36.6	0.0000
shrub agave present	0.2	0.4	1.0	1.3	-0.4	0.0000

Table 11. Descriptive statistics of variables used to build logistic regression models of buff-breasted flycatcher habitat: values for used areas, Chiricahua Mountains, 1996.

variable	mean	standard deviation	range	skewness	kurtosis	significance of Lilliefors
% cover coffeeberry, 1-2 m	0.05	0.23	1.0	3.9	14.5	0.0000
% cover oak, 0-1 m	0.35	0.67	3.0	2.1	4.2	0.0000
% total live cover, 0-1 m	13.3	6.8	28.0	0.7	-0.1	0.0009
no. of trees 20-30 cm dbh	8.8	3.8	17.0	0.3	-0.4	0.1910
% cover alligator juniper, 2-5 m	3.8	3.5	17.0	1.5	3.0	0.0000
% cover douglas-fir, 1-2 m	0.02	0.14	1.0	7.3	54.0	0.0000
% cover apache and chihuahua pine, 2-5 m	2.1	2.4	9.0	1.4	1.1	0.0000
no. of apache and chihuahua pines, 50-60 cm dbh	0.9	1.0	3.0	0.8	-0.4	0.0000
% cover leaf litter	20.8	5.5	24.0	-0.9	0.4	>0.2000
vigor of tallest netleaf oak	3.5	0.5	1.0	0.0	-6.0	0.1896
no. of apache and chihuahua pines, 40-50 cm dbh	1.7	1.9	8.0	1.4	1.5	0.0000
vigor of tallest white pine	4.1	0.8	2.0	-0.2	-1.0	>0.2000
shrub manzanita present	0.15	0.36	2.0	2.0	2.2	0.0000
shrub Arizona grape present	0.6	0.5	1.0	-0.4	-1.9	0.0000
shrub Arizona creeper present	0.1	0.3	1.0	2.5	4.6	0.0000
shrub agave present	0.1	0.3	1.0	2.9	6.6	0.0000

Table 12. Descriptive statistics of variables used to build logistic regression models of buff-breasted flycatcher habitat: values for nest sites, Chiricahua Mountains, 1996.

variable	mean	standard deviation	range	skewness	kurtosis	significance of Lilliefors
Vigor of tallest Arizona white oak	3.1	0.9	4.0	-1.8	4.9	0.0307
No. of shrub species	7.5	3.6	14.0	0.6	0.004	0.1981
% cover alligator juniper, 1-2 m	0.1	0.4	1.0	2.0	2.3	0.0000
% cover leaf litter	23.7	3.5	12.0	-0.57	-0.5	>0.2000
No. of oak trees, 10-20 cm dbh	6.0	6.5	22.0	1.1	0.11	0.0792
Dbh of tallest sycamore	64.0	24.9	73.0	-0.1	-1.4	>0.2000
% cover small dead branch, 0-1 m	0.1	0.3	1.0	2.5	4.9	0.0000
Shrub silktassel present	0.08	0.3	1.0	3.4	10.1	0.0000
Shrub pinion pine present	0.5	0.5	1.0	0.0	-2.2	0.0000

Appendix A. List of variables measured on buff-breasted flycatcher nest sites, used areas, and available areas in the Huachuca and Chiricahua mountains, 1995-1996.

DTR: distance to the primary riparian area in the canyon.
DTO: distance to an area > .04 ha without vegetation exceeding 10 m in height.
SLO: slope.
SLPO: slope position.
ELEV: elevation
ASP: aspect

The following variables were measured only at nest sites:

NTS: nest tree species.
NTH: nest tree height.
NTDBH: nest tree dbh.
NH: nest height.
NDTR: nest distance from trunk.
NDRTR: nest direction from trunk.
NDEF: distance from the nest to the distal ends of the branches of the nest tree.
NDUV: distance from the rim of the nest up to the closest vegetation.
NDSB: diameter of branch supporting the nest.

The following variables (with a capital "P" for the third letter) represent point-intercept data. The data are entered as the number of "hits" in 29 vertical point-intercept lines in the 15-m radius circle.

AAP1: Arbutus arizonica, 0-1 m
AAP2: Arbutus arizonica, 1-2 m
AAP3: Arbutus arizonica, 2-5 m
AAP4: Arbutus arizonica, 5-10 m
AAP5: Arbutus arizonica, >10 m
APP1: Arctostaphylos pungens, 0-1 m
APP2: Arctostaphylos pungens, 1-2 m
AVP1: Agave parryi, 0-1 m
BEP1: Nolina microcarpa, 0-1 m
CBP1: Cercocarpus betuloides, 0-1 m
CBP2: Cercocarpus betuloides, 1-2 m
CBP3: Cercocarpus betuloides, 2-5 m
CBP4: Cercocarpus betuloides, 5-10 m
CFP1: Ceanothus fendleri, 0-1 m
DFP1: dead forb, 0-1 m
DTP1: dead tree, 0-1 m
DTP2: dead tree, 1-2 m
DPT3: dead tree, 2-5 m
DPT4: dead tree, 5-10 m
DTP5: dead tree, > 10 m
FCP1: Populus fremontii, 0-1 m

FCP2: Populus fremontii, 1-2 m
FCP3: Populus fremontii, 2-5 m
FPC4: Populus fremontii, 5-10 m
FCP5: Populus fremontii, > 10 m
FOP1: forb, 0-1 m
FSP1: Fraxinus velutina, 0-1 m
FSP2: Fraxinus velutina, 1-2 m
FSP3: Fraxinus velutina, 2-5 m
FSP4: Fraxinus velutina, 5-10 m
FSP5: Fraxinus velutina, > 10 m
GDP1: bare ground
GRP1: grass, 0-1 m
GWP1: Garrya wrightii, 0-1 m
GWP2: Garrya wrightii, 1-2 m
GWP3: Garrya wrightii, 2-5 m
JDP1: Juniperus deppeana, 0-1 m
JDP2: Juniperus deppeana, 1-2 m
JDP3: Juniperus deppeana, 2-5 m
JDP4: Juniperus deppeana, 5-10 m
JDP5: Juniperus deppeana, > 10 m
JMP1: Juglans major, 0-1 m
JMP2: Juglans major, 1-2 m
JMP3: Juglans major, 2-5 m
JMP4: Juglans major, 5-10 m
LLP1: leaf litter
PCP1: Pinus cembroides, 0-1 m
PCP2: Pinus cembroides, 1-2 m
PCP3: Pinus cembroides, 2-5 m
PCP4: Pinus cembroides, 5-10 m
PCP5: Pinus cembroides, > 10 m
PEP1: Pinus englemanii, 0-1 m
PEP2: Pinus englemanii, 1-2 m
PEP3: Pinus englemanii, 2-5 m
PEP4: Pinus englemanii, 5-10 m
PEP5: Pinus englemanii, > 10 m
PLP1: Pinus leiophyllus, 0-1 m
PLP2: Pinus leiophyllus, 1-2 m
PLP3: Pinus leiophyllus, 2-5 m
PLP4: Pinus leiophyllus, 5-10 m
PLP5: Pinus leiophyllus, > 10 m
PMP1: Pseudotsuga mensiesii, 0-1 m
PMP2: Pseudotsuga mensiesii, 1--2 m
PMP3: Pseudotsuga mensiesii, 2-5 m
PMP4: Pseudotsuga mensiesii, 5-10 m
PMP5: Pseudotsuga mensiesii, > 10 m
PSP1: Pinus strobiformis, 0-1 m

PSP2: Pinus strobiformis, 1-2 m
PSP3: Pinus strobiformis, 2-5 m
PSP4: Pinus strobiformis, 5-10 m
PSP5: Pinus strobiformis, > 10 m
PVP1: Prunus virginiana, 0-1 m
PVP2: Prunus virginiana, 1-2 m
PVP3: Prunus virginiana, 2-5 m
PVP4: Prunus virginiana, 5-10 m
QEP1: Quercus emoryi, 0-1 m
QEP2: Quercus emoryi, 1-2 m
QEP3: Quercus emoryi, 2-5 m
QEP4: Quercus emoryi, 5-10 m
QEP5: Quercus emoryi, > 10 m
QGP1: Quercus gambeli, 0-1 m
QGP2: Quercus gambeli, 1-2 m
QGP3: Quercus gambeli, 2-5 m
QGP4: Quercus gambeli, 5-10 m
QGP5: Quercus gambeli, > 10 m
QHP1: Quercus hypoleucoides, 0-1 m
QHP2: Quercus hypoleucoides, 1-2 m
QHP3: Quercus hypoleucoides, 2-5 m
QHP4: Quercus hypoleucoides, 5-10 m
QHP5: Quercus hypoleucoides, > 10 m
QRP1: Quercus reticulata, 0-1 m
QRP2: Quercus reticulata, 1-2 m
QRP3: Quercus reticulata, 2-5 m
QRP4: Quercus reticulata, > 10 m
QZP1: Quercus arizonica, 0-1 m
QZP2: Quercus arizonica, 1-2 m
QZP3: Quercus arizonica, 2-5 m
QZP4: Quercus arizonica, 5-10 m
QZP5: Quercus arizonica, > 10 m
TRP1: Rhus radicans, 0-1 m
RMP1: Rubus neomexicana, 0-1 m
RMP2: Rubus neomexicana, 1-2 m
RNP1: Robinia neomexicana, 0-1 m
RNP2: Robinia neomexicana, 1-2 m
RNP3: Robinia neomexicana, 2-5 m
RNP4: Robinia neomexicana, 5-10 m
ROP1: rock
RTP1: Rhus trilobata, 0-1 m
RTP2: Rhus trilobata, 1-2 m
RVP1: Rhus choriophylla, 0-1 m
RVP2: Rhus choriophylla, 1-2 m
SOP1: Dasylirion wheeleri, 1-2 m
VAP1: Vitis arizonica, 0-1 m

VAP2: Vitis arizonica, 1-2 m
VAP3: Vitis arizonica, 1-5 m
VAP4: Vitis arizonica, 5-10 m
YUP1: Yucca schottii, 0-1 m
YUP2: Yucca schottii, 1-2 m
WAP1: water
SAP1: Salix sp., 0-1 m
SAP2: Salix sp., 1-2 m
SAP3: Salix sp., 2-5 m
RBP1: Rhamnus californica, 0-1 m
RBP2: Rhamnus californica, 1-2 m
SDB1: small (< 2 cm diameter) dead branch, 0-1 m
SDB2: small (< 2 cm diameter) dead branch, 1-2 m
SDB3: small (< 2 cm diameter) dead branch, 2-5 m
SDB4: small (< 2 cm diameter) dead branch, 5-10 m
MDB1: medium (2-10 cm diameter) dead branch, 0-1 m
MDB2: medium (2-10 cm diameter) dead branch, 1-2 m
MDB3: medium (2-10 cm diameter) dead branch, 2-5 m
MDB4: medium (2-10 cm diameter) dead branch, 5-10 m
LDB1: large (> 10 cm diameter) dead branch, 0-1 m
LDB2: large (> 10 cm diameter) dead branch, 1-2 m
LDB3: large (> 10 cm diameter) dead branch, 2-5 m
LDB4: large (> 10 cm diameter) dead branch, 5-10 m
CAP1: Cupressus arizonica, 0-1 m
CAP2: Cupressus arizonica, 1-2 m
CAP3: Cupressus arizonica, 2-5 m
CAP4: Cupressus arizonica, 5-10 m
CAP5: Cupressus arizonica, > 10 m
OPP1: Opuntia sp., 0-1 m
PTP3: Populus tremuloides, 2-5 m
PWP1: Platanus wrightii, 0-1 m
PWP2: Platanus wrightii, 1-2 m
PWP3: Platanus wrightii, 2-5 m
PWP4: Platanus wrightii, 5-10 m
PWP5: Platanus wrightii, > 10 m
TOAK1: oak species in aggregate, 0-1 m
TOAK2: oak species in aggregate, 1-2 m
TOAK3: oak species in aggregate, 2-5 m
TOAK4: oak species in aggregate, 5-10 m
TOAK5: oak species in aggregate, > 10 m
TOAK: oak species in aggregate, all heights
TPINE1: Pinus englemanii and Pinus leiophyllus in aggregate, 0-1 m
TPINE2: Pinus englemanii and Pinus leiophyllus in aggregate, 1-2 m
TPINE3: Pinus englemanii and Pinus leiophyllus in aggregate, 2-5 m
TPINE4: Pinus englemanii and Pinus leiophyllus in aggregate, 5-10 m
TPINE5: Pinus englemanii and Pinus leiophyllus in aggregate, > 10 m

TPINE: Pinus englemanii and Pinus leiophyllus in aggregate, all heights
OTHDEC1: deciduous trees other than oaks, 0-1 m
OTHDEC2: deciduous trees other than oaks, 1-2 m
OTHDEC3: deciduous trees other than oaks, 2-5 m
OTHDEC4: deciduous trees other than oaks, 5-10 m
OTHDEC5: deciduous trees other than oaks, > 10 m
SHRUB1: any shrub, 0-1 m
SHRUB2: any shrub, 1-2 m
SHRUB3: any shrub, 2-5 m
SHRUB4: any shrub, 5-10 m
TLC1: total live cover, 0-1 m
TLC2: total live cover, 1-2 m
TLC3: total live cover, 2-5 m
TLC4: total live cover, 5-10 m
TLC5: total live cover, > 10 m
AAHGT: Arbutus arizonica, height of tallest specimen in plot
AADBH: Arbutus arizonica, dbh of tallest specimen in plot
AAVIG: Arbutus arizonica, vigor of tallest specimen in plot
AAT1: number of Arbutus arizonica 10-20 cm dbh
AAT2: number of Arbutus arizonica 20-30 cm dbh
AAT3: number of Arbutus arizonica 30-40 cm dbh
AAT4: number of Arbutus arizonica 40-50 cm dbh
AAT5: number of Arbutus arizonica 50-60 cm dbh
AATOT: number of Arbutus arizonica
CBHGT: Cercocarpus betuloides, height of tallest specimen in plot
CBDBH: Cercocarpus betuloides, dbh of tallest specimen in plot
CBT1: number of Cercocarpus betuloides 10-20 cm dbh
CBT2: number of Cercocarpus betuloides 20-30 cm dbh
CBTOT: number of Cercocarpus betuloides
DTHGT: dead tree, height of tallest specimen in plot
DTDBH: dead tree, dbh of tallest specimen in plot
AAVIG: dead tree, vigor of tallest specimen in plot
DTT1: number of dead trees, 10-20 cm dbh
DTT2: number of dead trees, 20-30 cm dbh
DTT3: number of dead trees, 30-40 cm dbh
DTT4: number of dead trees, 40-50 cm dbh
DTT5: number of dead trees, 50-60 cm dbh
DTT6: number of dead trees, > 61 cm dbh
DTTOT: number of dead trees
FSHGT: Fraxinus velutina, height of tallest specimen in plot
FSDBH :Fraxinus velutina, dbh of tallest specimen in plot
FSVIG: Fraxinus velutina, vigor of tallest specimen in plot
FST1: number of Fraxinus velutina, 10-20 cm dbh
FST2: number of Fraxinus velutina, 20-30 cm dbh
FST3: number of Fraxinus velutina, 30-40 cm dbh
FST4: number of Fraxinus velutina, 40-50 cm dbh

FST5: number of Fraxinus velutina, 50-60 cm dbh
FSTOT: number of Fraxinus velutina
JDHGT: Juniperus deppeana, height of tallest specimen in plot
JDDBH: Juniperus deppeana, dbh of tallest specimen in plot
JDVIG: Juniperus deppeana, vigor of tallest specimen in plot
JDT1: number of Juniperus deppeana, 10-20 cm dbh
JDT2: number of Juniperus deppeana, 20-30 cm dbh
JDT3: number of Juniperus deppeana, 30-40 cm dbh
JDT4: number of Juniperus deppeana, 40-50 cm dbh
JDT5: number of Juniperus deppeana, 50-60 cm dbh
JDT6: number of Juniperus deppeana, > 60 cm dbh
JDTOT: number of Juniperus deppeana
JMHGT: Juglans major, height of tallest specimen in plot
JMDBH: Juglans major, dbh of tallest specimen in plot
JMVIG: Juglans major, vigor of tallest specimen in plot
JMT1: number of Juglans major, 10-20 cm dbh
JMT2: number of Juglans major, 20-30 cm dbh
JMT3: number of Juglans major, 30-40 cm dbh
JMTOT: number of Juglans major
PCHGT: Pinus cembroides, height of tallest specimen in plot
PCDBH: Pinus cembroides, dbh of tallest specimen in plot
PCVIG: Pinus cembroides, vigor of tallest specimen in plot
PCT1: number of Pinus cembroides, 10-20 cm dbh
PCT2: number of Pinus cembroides, 20-30 cm dbh
PCT3: number of Pinus cembroides, 30-40 cm dbh
PCT5: number of Pinus cembroides, 40-50 cm dbh
PCTOT: number of Pinus cembroides
PEGHT: Pinus englemanii, height of tallest specimen in plot
PEDBH: Pinus englemanii, dbh of tallest specimen in plot
PEVIG: Pinus englemanii, vigor of tallest specimen in plot
PET1: number of Pinus englemanii, 10-20 cm dbh
PET2: number of Pinus englemanii, 20-30 cm dbh
PET3: number of Pinus englemanii, 30-40 cm dbh
PET4: number of Pinus englemanii, 40-50 cm dbh
PET5: number of Pinus englemanii, 50-60 cm dbh
PET6: number of Pinus englemanii, > 60 cm dbh
PETOT: number of Pinus englemanii
PLGHT: Pinus leiophyllus, height of tallest specimen in plot
PLDBH: Pinus leiophyllus, dbh of tallest specimen in plot
PLVIG: Pinus leiophyllus, vigor of tallest specimen in plot
PLT1: number of Pinus leiophyllus, 10-20 cm dbh
PLT2: number of Pinus leiophyllus, 20-30 cm dbh
PLT3: number of Pinus leiophyllus, 30-40 cm dbh
PLT4: number of Pinus leiophyllus, 40-50 cm dbh
PLT5: number of Pinus leiophyllus, 50-60 cm dbh
PLT6: number of Pinus leiophyllus, > 60 cm dbh

PLTOT: number of Pinus leiophyllus
PMHGT: Pseudotsuga mensiesii, height of tallest specimen in plot
PMDBH: Pseudotsuga mensiesii, dbh of tallest specimen in plot
PMVIG: Pseudotsuga mensiesii, vigor of tallest specimen in plot
PMT1: number of Pseudotsuga mensiesii, 10-20 cm dbh
PMT2: number of Pseudotsuga mensiesii, 20-30 cm dbh
PMT3: number of Pseudotsuga mensiesii, 30-40 cm dbh
PMT4: number of Pseudotsuga mensiesii, 40-50 cm dbh
PMT5: number of Pseudotsuga mensiesii, 50-60 cm dbh
PMT6: number of Pseudotsuga mensiesii, > 60 cm dbh
PMTOT: number of Pseudotsuga mensiesii
PSHGT Pinus strobiformis:, height of tallest specimen in plot
PSDBH: Pinus strobiformis, dbh of tallest specimen in plot
PSVIG: Pinus strobiformis, vigor of tallest specimen in plot
PST1: number of Pinus strobiformis, 10-20 cm dbh
PST2: number of Pinus strobiformis, 20-30 cm dbh
PST3: number of Pinus strobiformis, 30-40 cm dbh
PST5: number of Pinus strobiformis, 40-50 cm dbh
PSTOT: number of Pinus strobiformis
PVHGT: Prunus virginiana, height of tallest specimen in plot
PVDBH: Prunus virginiana, dbh of tallest specimen in plot
PVVIG: Prunus virginiana, vigor of tallest specimen in plot
PVT1: number of Prunus virginiana, 10-20 cm dbh
PVT3: number of Prunus virginiana, 30-40 cm dbh
PVT5: number of Prunus virginiana, 50-60 cm dbh
PVTOT:number of Prunus virginiana
PWHGT: Platanus wrightii, height of tallest specimen in plot
PWDBH: Platanus wrightii, dbh of tallest specimen in plot
PWVIG: Platanus wrightii, vigor of tallest specimen in plot
PWT1: number of Platanus wrightii, 10-20 cm dbh
PWT2: number of Platanus wrightii, 20-30 cm dbh
PWT3: number of Platanus wrightii, 30-40 cm dbh
PWT4: number of Platanus wrightii, 40-50 cm dbh
PWT5: number of Platanus wrightii, 50-60 cm dbh
PWT6: number of Platanus wrightii, > 60 cm dbh
PWTOT: number of Platanus wrightii
QZHGT: Quercus arizonica, height of tallest specimen in plot
QZDBH: Quercus arizonica, dbh of tallest specimen in plot
QZVIG: Quercus arizonica, vigor of tallest specimen in plot
QZT1: number of Quercus arizonica, 10-20 cm dbh
QZT2: number of Quercus arizonica, 20-30 cm dbh
QZT3: number of Quercus arizonica, 30-40 cm dbh
QZT4: number of Quercus arizonica, 40-50 cm dbh
QZT5: number of Quercus arizonica, 50-60 cm dbh
QZT6: number of Quercus arizonica, > 60 cm dbh
QZTOT: number of Quercus arizonica

QEHGT: Quercus emoryi , height of tallest specimen in plot
QEDBH: Quercus emoryi, dbh of tallest specimen in plot
QEVIG: Quercus emoryi, vigor of tallest specimen in plot
QET1: number of Quercus emoryi, 10-20 cm dbh
QET2: number of Quercus emoryi, 20-30 cm dbh
QET3: number of Quercus emoryi, 30-40 cm dbh
QET4: number of Quercus emoryi, 40-50 cm dbh
QETOT: number of Quercus emoryi
QGHGT: Quercus gambeli, height of tallest specimen in plot
QGDBH: Quercus gambeli, dbh of tallest specimen in plot
QGVIG: Quercus gambeli, vigor of tallest specimen in plot
QGT1: number of Quercus gambeli, 10-20 cm dbh
QGT2: number of Quercus gambeli, 20-30 cm dbh
QGT3: number of Quercus gambeli, 30-40 cm dbh
QGT4: number of Quercus gambeli, 40-50 cm dbh
QGTOT: number of Quercus gambeli
QHHGT: Quercus hypoleucoides, height of tallest specimen in plot
QHDBH: Quercus hypoleucoides, dbh of tallest specimen in plot
QHVIG: Quercus hypoleucoides, vigor of tallest specimen in plot
QHT1: number of Quercus hypoleucoides, 10-20 cm dbh
QHT2: number of Quercus hypoleucoides, 20-30 cm dbh
QHT3: number of Quercus hypoleucoides, 30-40 cm dbh
QHT4: number of Quercus hypoleucoides, 40-50 cm dbh
QHT5: number of Quercus hypoleucoides, 50-60 cm dbh
QHTOT: number of Quercus hypoleucoides
QRHGT: Quercus reticulata, height of tallest specimen in plot
QRDBH: Quercus reticulata, dbh of tallest specimen in plot
QRVIG: Quercus reticulata, vigor of tallest specimen in plot
QRT1: number of Quercus reticulata, 10-20 cm dbh
QRT2: number of Quercus reticulata, 20-30 cm dbh
QRT3: number of Quercus reticulata, 30-40 cm dbh
QRT4: number of Quercus reticulata, 40-50 cm dbh
QRTOT: number of Quercus reticulata
DBH1T: total number of trees, 10-20 cm dbh
DBH2T: total number of trees, 20-30 cm dbh
DBH3T: total number of trees, 30-40 cm dbh
DBH4T: total number of trees, 40-50 cm dbh
DBH5T: total number of trees, 50-60 cm dbh
DBH6T: total number of trees, > 60 cm dbh
GRNDTOT: total number of trees
SHSPTOT: number of shrub species
SHAA: Arbutus arizonica, present as a shrub
SHAP: Arctostaphylos pungens, present as a shrub
SHAV: Agave parryi, present as a shrub
SHBL: Baccharis glutinosa, present as a shrub
SHCB: Cercocarpus betuloides, present as a shrub

SHCF: Ceanothus fendleri, present as a shrub
SHCT: Echinocactus sp., present as a shrub
SHFC: Populus fremontii, present as a shrub
SHFS: Fraxinus velutina, present as a shrub
SHGW: Garrya wrightii, present as a shrub
SHJD: Juniperus deppeana, present as a shrub
SHJM : Juglans major, present as a shrub
SHLO: Lonicera arizonica, present as a shrub
SHPC Pinus cembroides, present as a shrub
SHPE : Pinus englemanii, present as a shrub
SHPL : Pinus leiophyllus, present as a shrub
SHPM : Pseudotsuga mensiesii, present as a shrub
SHPS : Pinus strobiformis, present as a shrub
SHPV : Prunus virginiana, present as a shrub
SHPW : Platanus wrightii, present as a shrub
SHQE : Quercus emoryi, present as a shrub
SHQG : Quercus gambeli, present as a shrub
SHQH : Quercus hypoleucoides, present as a shrub
SHQR : Quercus reticulata, present as a shrub
SHQZ : Quercus arizonica, present as a shrub
SHRM : Rubus neomexicana, present as a shrub
SHRN : Robinia neomexicana, present as a shrub
SHRT : Rhus trilobata, present as a shrub
SHRV : Rhus choriophylla, present as a shrub
SHSA : Salix sp., present as a shrub
SHSO : Dasylirion wheeleri, present as a shrub
SHTR : Rhus radicans, present as a shrub
SHYU : Yucca schottii, present as a shrub
SHBE : Nolina microcarpa, present as a shrub
SHOP: Opuntia sp., present as a shrub
SHVA : Vitis arizonica, present as a shrub
SHMB: Mimosa biuncifera, present as a shrub
SHVC: Parthenocissus arizonica, present as a shrub
SHOL: unidentified leguminous shrub, present
SHRB: Rhamnus californica, present as a shrub
OAKT1: all oak tree species in aggregate, 10-20 cm dbh
OAKT2: all oak tree species in aggregate, 20-30 cm dbh
OAKT3: all oak tree species in aggregate, 30-40 cm dbh
OAKT4: all oak tree species in aggregate, 40-50 cm dbh
OAKT5: all oak tree species in aggregate, 50-60 cm dbh
OAKT6: all oak tree species in aggregate, > 60 cm dbh
OAKT: all oak tree species in aggregate
PINET1: Pinus englemanii and Pinus leiophyllus in aggregate, 10-20 cm dbh
PINET2: Pinus englemanii and Pinus leiophyllus in aggregate, 20-30 cm dbh
PINET3: Pinus englemanii and Pinus leiophyllus in aggregate, 30-40 cm dbh
PINET4: Pinus englemanii and Pinus leiophyllus in aggregate, 40-50 cm dbh

PINET5: Pinus englemanii and Pinus leiophyllus in aggregate, 50-60 cm dbh
PINET6: Pinus englemanii and Pinus leiophyllus in aggregate, > 60 cm dbh
PINET: Pinus englemanii and Pinus leiophyllus in aggregate

Appendix B. Conversions from metric to English units.

Linear measure

1 inch = 2.54 centimeters (cm)
1 foot = 0.3048 meters (m)
1 yard = 0.9144 meters
1 mile = 1.6093 kilometers (km)

Square measure

1 acre = 0.405 hectares (ha)